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Survey of Lubricating Grease Test Methods

By Carl W. Georgi

Chairman, Technical Committee, National Lubricating Grease Institute

The Technical Sub-Committee on Test Methods was appointed by the Board of Directors of the National Lubricating Grease Institute and was instructed to conduct a survey on Lubricating Grease Test Methods and to submit a report at the October 1942 annual meeting.

The survey was conducted by means of questionnaire and personal interviews with grease manufacturers and larger industrial and automotive consumers. Approximately forty laboratories submitted information and it is believed therefore that the survey is adequately comprehensive and represents the status of lubricating grease tests methods as they exist at the present time. Since lubricating greases for the war effort are of major concern, test methods as contained in the lubricating grease specifications of the various Government agencies and Armed Forces were also included as a part of the survey.

This paper is not a formal report of the Sub-Committee, but is a compilation of the data secured from the survey and a discussion of same as prepared by the author. The statements and conclusions presented herein are accordingly those of the author and may not represent the attitude of the Institute.

Table I is an outline of the lubricating grease test methods which were included in the survey.

Table 1

Survey
Grease Test Methods

I Consistency and Mobility
II Dropping Point
III Stability
  (a) Change on Working
  (b) Oxidation
  (c) Separation
  (d) Corrosion
IV Texture
  (a) Fibre Length
  (b) Adhesiveness
V Analysis
  (a) Water Content
  (b) Impurities
  (c) Free Acid and Free Alkali
VI Low Temperature Tests
VII Performance Tests

Consistency Tests

Table II shows the different types of penetration tests which are being used at the present time. The survey has revealed an interesting fact in that the A. S. T. M. Penetrometer is the only grease test device which appears to be in universal use. While the A.S.T.M. has standardized a number of grease test methods, the survey has indicated that most of these have not been adopted widely, but every laboratory dealing to any extent with grease apparently uses the A.S.T.M. Penetrometer.

NOTE

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Table 2

Penetration Tests

A.S.T.M. Penetrometer
—Method D-217
  150 gram dropping weight.
Modified A.S.T.M. Penetrometer
—Various cone weights
  (25, 30, 38, 50, 70, 75,
  200, 300 grams)
Modified A.S.T.M. Penetrometer
—Perforated discs
  substituted for cone
Texaco Miniature Penetrometer
Shell Miniature Penetrometer
A.B.E.C. Miniature Penetrometer

Numerous modifications of the A.S.T.M. Penetrometer using light weight cones varying anywhere from 25 to 75 grams in weight are also in use. The light weight cone modification has come into practice for the control and specification of the very soft, semi-fluid type greases which cannot be tested by the standard A.S.T.M. Penetrometer with the 150 gram cone. Likewise, heavier cone weights, in the order of 200 and 300 grams, have been utilized for penetration measurement of very hard, block type greases.

Miniature penetrometers, such as the Texaco and Bearing Engineers Committee devices, have been utilized where only small grease samples were available, such as used samples from bearings, etc.

All of the penetrometers listed in Table II are essentially mechanical "fingers" to provide more precise and reproducible means for designating greases as to whether they are soft, medium, hard, extra hard, etc.

(Continued on page 4)

Wheel Bearing Lubrication

By J. HOWARD PILE
CHEK-CHART Editorial Director

Automotive wheel bearings are invariably of the anti-friction type. That is, they are either ball bearings or roller bearings. There are no plain bearing types used in the wheels of any automotive vehicles.

The earlier days of automotive history indicate that no particular trouble was experienced in lubricating wheel bearings with almost any type of lubricant.

However, the advent of four-wheel brakes and the change from the external type brake to the internal type brake involved additional difficulties due to higher temperatures brought about by the braking action itself. Coupled with this are the higher speeds of modern automobiles which bring severe requirements in the way of quick stopping. Bringing a vehicle moving at 60 mph down to a dead stop, under emergency conditions, creates a considerable amount of heat in the region of the brake mechanism which is quite close to the wheel bearings. Heat is, therefore, transferred to the wheel bearings.

These conditions brought about the necessity for a lubricant which would not only stand up under heat conditions, but which would remain in the bearing for a considerable time without the necessity of frequent attention.

The oil industry has had, for many years, lubricants of this type, known as wheel bearing greases. They are usually of the soda base type, short fiber greases especially efficient for wheel bearing lubrication. There is also another type of soda base grease, of a slightly different composition, used for some universal joints and this type of soda base grease is known as a long fiber grease to distinguish it from the short fiber wheel bearing greases.

FIBER GREASES

The fiber greases, both wheel bearing and universal joint type, are known as high melting point greases and have melting points ranging upward from 300° F. This makes them admirably adapted for the conditions under which they will have to operate in the presence of heat generated by the braking mechanism. Cup greases and chassis lubricants, while they will perform satisfactorily at normal atmospheric temperatures, will not give satisfaction under operating conditions where temperatures are higher. Most cup greases have a melting point not much in excess of 200° F.

Another feature of the modern fiber type wheel bearing grease is that its stringy consistency makes it adhere closely to the metal surfaces of the anti-friction bearings and prevents it from being squeezed out.

In modern high speed vehicles, heat is also generated in the actual operation of the anti-friction bearing itself. While the amount of friction between the ball, or roller bearing, and its race is small, yet there is friction which results in some heat. Added to this is the friction generated by the bearing separator and also by the fact that the weight of the vehicle causes a slight deformation of the ball, or roller bearing at the time the maximum load is applied and a return to normal shape after the peak load has passed. This also generates heat.

Front wheels of all passenger cars, and practically all trucks, have to be lubricated by dismounting the wheel and the bearing. Some of the older types of passenger cars and a few trucks could be lubricated by introducing the lubricant through a fitting into the front wheel hub.

The modern method of lubricating a front wheel bearing, however, involves disassembling the bearing, washing the parts in solvent and repacking the bearing with wheel bearing grease. The amount of grease to be applied is only that necessary to completely pack the spaces between the balls or rollers and their races. Any extra grease placed in the hub cavity, or in the hub cap, is simply wasted. It does no good at all, and may even be thrown over to one side of the hub causing an unbalanced condition of the wheel. This may seem like an item of small moment, yet on the other hand, some hub cavities are sufficiently large so that 1 lb. of lubricant may be easily thrown several inches off center and, at high speeds, this may even result in wabble, shimmy and tramp.

The proper adjustment of front wheel bearings is part of the service that is just as important as the proper lubrication.

Rear wheel bearings of automotive vehicles are lubricated by several different methods, namely:

- Lubricated through fittings
- Lubricated through grease cups
- Lubricated by gear lubricant from differential housing
- Lubricated by removing wheels and bearings and hand packing, the same as front wheel bearings
- Lubricated by prepacked bearing assembled and sealed with sufficient lubricant to last the life of the car

From this it can be seen that only in two cases can the proper procedure for rear wheel bearing lubrication be found out from observation, that is, in the case of fittings or grease cups. In other cases it is necessary to know the construction or the method of lubricant supply in order to apply the proper lubrication service. Instructions covering the exact procedure is to be found on each CHEK-CHART Lubrication Chart.

Rear wheel bearings which are lubricated by fittings or grease cups, require attention at the mileages indicated by the manufacturer. In the case of the fitting, the lubricant should be applied with a low pressure gun so as not to endanger grease seals or to force wheel bearing grease either into the brake drum compartment or back into the differential housing. High pressure grease guns should never be used on rear wheel bearings.

REPACKING GREASE CUPS

Grease cups are to be turned down one or two turns at the mileage interval recommended by the manufacturer, as shown on the charts, and when the grease cup can no longer be turned down it should be carefully cleaned off and refilled with wheel bearing grease.

Rear wheel bearings which are automatically lubricated from the differential require no further attention, except for possible normal wear and adjustment. The gear lubricant is automatically fed in sufficient quantities to the bearings to insure adequate lubrication. This is usually accomplished by a spiral device on the axle shaft which keeps pushing gear lubricant back to the region of the wheel bearings.

The only trouble that can possibly come up on this type of construction is allowing the level in the differential housing to become too low, or using a gear lubricant which is too thick to be moved by the feeding device.

Bearings which require dismounting should be treated the same as front wheel bearings. The bearings should be washed in solvent and repacked by hand.

Prelubricated bearings either require no lubrication for the life of the car, or may possibly carry a recommendation of relubrication at extended mileage intervals such as every 30,000 miles.

REPLACEMENT OF SEALS

In both front and rear wheel bearings, the grease seals are a vitally important part of the mechanism. The action of removing either front or rear wheels should be done with great care so as not to damage or mar the surfaces of the grease seal. Furthermore, grease seals will normally wear and, after a time, will permit grease to escape

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between the inner diameter of the seal and the shaft. Whenever wheel bearings are relubricated, worn or defective grease seals should be replaced with new ones. The cost of the seal is small compared to the cost of dismounting, relubricating and adjusting the wheel bearings.

On many rear wheel bearings, where the wheel has to be removed for lubrication of the bearings, it is necessary to have a wheel puller and, inasmuch as there are a variety of different constructions on different cars and trucks, any shop which contemplates lubrication of different types of bearings will need to be provided with a complete set of pullers, which will pull all the different types of wheels.

Considerable advances have been made in the past few years in the development of wheel-bearing packing machines which considerably simplify both front and rear wheel bearing lubrication. These machines usually operate on the principle of forcing new grease into the bearing region which, at the same time, forces the old grease out. In other words, the old grease is really flushed out by the entry of the new grease. This action eliminates the necessity of washing with solvent and also prevents the possibility of dirt or grit being introduced into the bearing, which so often happens with the careless handling of bearing parts.

Wheel bearing lubrication is vitally important to the proper operation of automotive vehicles for several reasons.

In the first place, proper lubrication insures long life and satisfactory operation of the bearings themselves.

GREASE VS. BRAKES

In the second place, wheel bearing lubrication vitally effects brakes. It is estimated that 70% of all brake troubles are caused by faulty lubrication. Once grease gets on the brake linings, it is impossible to obtain satisfactory operation of the brakes without completely relining. If solvent is used on the brake linings to remove grease, it will also dissolve some of the active material from the brake linings, causing faulty operation and short life.

Further detailed information regarding specialized lubricants for wheel bearings, together with wheel bearing lubrication theories, are to be found in the Sixth Edition of Service Man's Guide to Automotive Lubrication. Manufacturer's exact recommendations as to mileage, time interval, and lubricant are contained on every CHEK-CHART Lubrication Chart.

Trade Items of Interest to Oil Men

Firestone Tire & Rubber Company has issued three booklets on "How To Get More Mileage From Your Tires." One is on truck tires, one on passenger car tires, and one on farm tractor and implement tires.

These bookets show dangers of under-inflation, over-loading, and other driving sins that take a heavy toll in decreased tire life. Truck tires, for example, 60% inflated waste 65% of the rubber, while a 40% overload wastes 50% of the rubber.

The booklets also give valuable hints on driving as to speeds; axle loads and sagging axles on trucks; changing of tires; and avoiding road hazards.

The B. F. Goodrich Company has issued an "Operator's Handbook" giving information on truck, bus, trailer, tractor, and implement tires.

The book contains much tabulation matter, on correct tire pressures, rim sizes, and loads. This information includes proper pressures for various types of trucks as store-door commercial, store-door heavy duty, commercial heavy duty, and so on.

Information is given also on driving habits, tire inflation and the dangers of neglecting proper air pressures.

MoToR, automobile trade magazine, announces publication of a new "Truck Repair Manual" for truck mechanics, repair shops, owners, fleet operators, and governmental agencies.

The manual contains 1400 pictures, charts and diagrams, 300,000 facts, and has 905 pages. Copies may be purchased from *MoToR* book department, 572 Madison Ave., New York City.

A report on recent tests conducted by a transport operator, on a nation-wide scale and with approval of the War Department, is given in the April issue of *Fleet Owner*, begining on page 64.

Fleet Owner has conducted a survey among fleet operators on wartime fuels, and comes up with some interesting ideas involving motor oil, including practices of more frequent draining of the crankcase, and the use of detergent oils to reduce hand labor in carbon cleaning.

Station operators and marketing officials will be interested in this practical, down-to-earth survey answers from 163 fleets. They show how operators are meeting wartime changes in gasoline, and what adjustments they are making in maintenance procedures. The article begins on page 46 of the April issue.

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(Continued from page 2)

Table III lists mobility and viscosity test methods which have been adapted by many laboratories for evaluating these properties of lubricating grease. The large number of test methods of this sort which are in use indicates a general dissatisfaction with consistency tests as measured by Penetrometer instruments and also indicates a desire by many technologists to learn more concerning the mobility or viscosity properties of greases as contrasted to mere designation by "finger" density.

TABLE 3
MOBILITY AND VISCOSITY TEST METHODS

Gardner Mobilometer
S.I.L. Mobilometer
Abraham Consistometer
Knopf Consistometer
Arveson Constant-Shear Viscosimeter
MacMichael Viscosimeter
Stormer Viscosimeter
Hoeppler Viscosimeter
Syncro-lectric Viscosimeter
Saybolt-Pressure Viscosimeter
S.O.D. Pressure Viscosimeter

The following are brief definitions of two properties which are related to the physical state of lubricating greases:

Consistency—Measure of relative resistance of a plastic material to permanent change of shape.

Mobility —Measure of the relative resistance of a plastic material to continuous deformation or flow after the yield value has been exceeded.

On the basis of these definitions, consistency is limited to the measurement of the resistance of a grease to a permanent change of shape which merely means a designation such as soft, medium or hard, etc. It is possible to prepare two greases of the same soap base which will have identical consistencies by the A.S.T.M. Penetrometer and yet these two greases may be entirely unlike as to their service performance characteristics. A typical example of such a condition would be two greases of the same soap base, one made with a very low viscosity mineral oil and the other with a very high viscosity mineral oil. Although these two greases could be made with identical A.S.T.M. penetrations, the product containing the light mineral oil would be primarily for low temperture use, whereas the one made with the viscous mineral oil would be much more suited for service at more elevated temperatures.

Since all greases, as soon as they are re-

TABLE 4
GREASE DROPPING POINT TEST METHODS

METHOD	DESCRIPTION	REFERENCE
Ubbelohde	Glass or Brass Cup of specified dimensions	Institute of Petroleum Technologists Method L.G.-11
Modified Ubbelohde	Brass Cup and fixture of specified dimensions	Proposed Method, A.S.T.M. 1937
Modified Ubbelohde	Film of grease in Brass Cup of specified dimensions	A.S.T.M. D566-40T
Steel Tube Method	Steel Tube $\frac{3}{16}$" I.D. x ¾" long	U. S. Army Specification
Steel Tube Method	Steel Tube ¼" I.D. x ½" long	Army Air Forces Specification
Thimble Method	Wire Mesh Thimble of specified dimensions	Car Manufacturer Specification
Glass Tube Method	Glass Tube 5 m.m. I.D. x 25 m.m. long	Car Manufacturer Specification
Coated Bulb Method	Thin layer of grease on thermometer bulb	F.B.S. No. 140.1 A.S.T.M. D-127
Wire Spiral Method	Wire spiral on thermometer bulb to secure uniform layer grease.	
Mercury Method	Grease heated on surface of crucible of Mercury	

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moved from their shipping containers, must be handled essentially as plastic fluids, the mobility properties are of great importance, if mobility is defined as the resistance of grease to continuous flow under pressure. This properly controls the ease with which a grease may be pumped from its container into the bearing or mechanism it is to lubricate and also controls the starting torque and the running torque of the mechanisms it lubricates. The general lack of information and knowledge concerning the mobility characteristics of greases is undoubtedly the reason why the wide variety of test methods as listed in Table III, have been developed and put into use in many grease laboratories.

The paper given by Dr. Zimmer and his associates on "The Flow Characteristics of Lubricating Greases" before the New Orleans meeting of the N.L.G.I. is an excellent contribution to the grease industry and points the way to a further expansion of knowledge concerning the mobility or flow properties of greases. The grease industry has been backward in developing test methods and resultant knowledge concerning the mobility and flow characteristics of greases and this problem deserves much greater attention than it has heretofore received.

TABLE 5

DROPPING POINTS

CALCIUM BASE GREASES

TEST METHOD	340 Penet. 800 Vis. Oil	280 Penet. 700 Vis. Oil	260 Penet. 300 Vis. Oil	200 Penet. 100 Vis. Oil
A.S.T.M. D-566	213°F.	201°F.	197°F.	231°F.
Ubbelohde	205°	204°	194°	226°
3/16"x3/4" Tube	210°	210°	200°	230°
1/4"x1/2" Tube	202°	206°	198°	232°
Spiral Wire on Bulb	210°	212°	202°	250°
Wire Thimble	196°	202°	193°	234°
Glass Tube (5x25 m.m.)	190°	200°	186°	224°

TABLE 6

DROPPING POINTS

SODA BASE GREASES

	280 Penet. 120 Vis. Oil	220 Penet. 120 Vis. Oil	260 Penet. 60 Vis. Oil	260 Penet. 90 Vis. Oil
A.S.T.M. D-566	295°	320°	305°	330°
Ubbelohde	330°	340°	330°	355°
Spiral Wire on Bulb	335°	345°	320°	370°
3/16"x3/4" Tube	235°	240°	235°	315°
1/4"x1/2" Tube	225°	250°	220°	260°
Wire Thimble	220°	255°	230°	280°
Glass Tube (5x25 mm.)	240°	280°	200°	240°

TABLE 7

DROPPING POINTS

ALUMINUM AND LITHIUM BASE GREASES

	Aluminum Base 360 Penet. 300 at 100° Oil	Aluminum Base 310 Penet. 150 at 210° Oil	Lithium Base Low Temperature Grease
A.S.T.M. D-566	200°	230°	360°
Ubbelohde	194°	230°	380°
Spiral Wire on Bulb	200°	260°	380°
3/16"x3/4" Tube	195°	230°	380°
1/4"x1/2" Tube	175°	220°	370°
Wire Thimble	190°	220°	285°
Glass Tube (5x25 mm.)	120°	185°	380°

GREASE DROPPING POINT TEST METHODS

Table IV lists Grease Dropping Point Test Methods in current use. A number of additional methods were reported by some laboratories but these were apparently only in use in isolated cases.

Although the A.S.T.M. has standardized the modified Ubbelohde Film-In-Cup Method it would appear that this procedure has not achieved universal use and many grease specifications still call for other types of dropping point tests. As an example, one grease manufacturer stated that his laboratory is forced to run dropping points by six different methods in order to comply with customers requirements.

Table V lists dropping points on a series of calcium base greases by seven different test methods. It will be noted that there is fairly good agreement between the different methods for the calcium base greases, although differences of as much as 2020° F. are indicated, depending upon the test method used.

Table VI shows dropping points of a series of soda base greases by seven different test methods. As shown, there is extremely poor agreement in dropping point values and differences of more than 100°F. are readily procured, depending upon the test method selected. Apparently, the test methods utilizing a thin film of grease, such as the A.S.T.M. or the thermometer bulb method, tend to show quite high dropping points for soda base greases, whereas the methods utilizing a tube or a thimble, wherein the grease is in a fairly large lump, tend to show considerably lower dropping point values.

Table VII shows similar dropping point data on typical aluminum base and lithium base greases. Here again there is a wide difference in melting point figures, depending upon the method used and variations in the order of 100°F. are readily produced.

These comparative dropping point data indicate the confused situation existing in the grease industry and it is apparent that any discussion of dropping points must include a specific mention of the method used, otherwise, serious deviations and misunderstandings can readily develop.

The fact that so many varieties of dropping point methods are in use would seem to indicate that A.S.T.M. Method D-566 is not considered wholly satisfactory by many manufacturers and consumers of greases. In examining the dropping point data it would appear in general that most test methods tend to show greases to have dropping points much higher than their maximum service operating temperatures. As an example, practically all calcium base

greases have dropping points in the order of 200°F. or higher by most dropping point test methods. On the other hand, very few calcium base greases would be recommended for use in many applications where the temperatures run consistently above 160°F. It would seem therefore that an important problem for the grease industry is a thorough review of the dropping point test situation in the direction of standardizing on a limited number of test methods and to institute a further study of the problem with the idea of developing a dropping point test method which will evaluate greases more nearly in line with their true maximum service operating temperatures. With some of the dropping point methods, it would appear their primary intent was to rate greases as having as high dropping point temperatures as possible, rather than to rate them in terms of their true service performance temperature limits.

MECHANICAL STABILITY TEST

Table VIII lists the various methods reported by the cooperating laboratories for evaluating the "change-on-working" properties of greases. Many laboratories appear to be working at the present time with modifications of the A.S.T.M. procedure for unworked and worked consistencies, by carrying on the working for a greater number of worker strokes than the 60 strokes specified in the present A.S.T.M. Procedure.

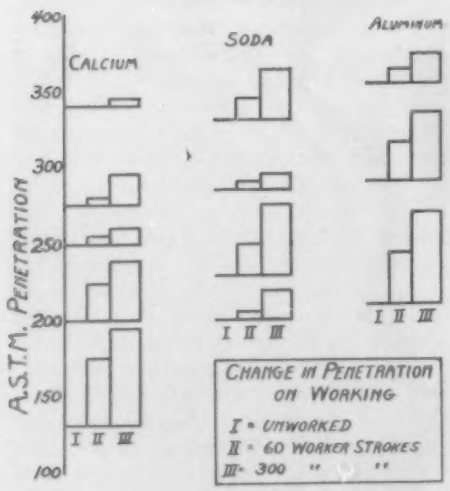
TABLE 8
MECHANICAL STABILITY TESTS
(Change on Working)

TEST
Change between A.S.T.M. Unworked and Worked Consistencies
Change in A.S.T.M. Consistencies at Successive Intervals of 60 Worker Strokes
Change in A.S.T.M. Consistencies up to 5000 Worker Strokes
A.B.E.C. Machine
Navy Grease Machine (Spec. 14-L-7)

The B.E.C. Grease Testing Machine and the Navy Grease Machine are used for evaluating the softening tendencies of greases upon operation in a ball bearing, but these machines appear to be in relatively limited use and the greatest amount of interest seems to lie in the use of the A.S.T.M. Grease Worker, operated up to as much as 5000 strokes.

Figure IX shows typical data on the change on working after 60 strokes and after 300 strokes in the A.S.T.M. Worker. With calcium base greases, the change in consistency with increased working seems to vary essentially with the grade of the grease. The softer grades of calcium base greases

FIGURE 9

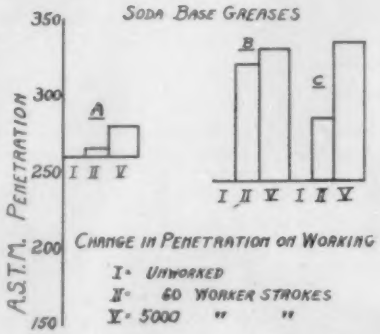


such as the #0 grade show relatively little break-down on working up to 300 worker strokes. On the other hand, the heavier grades such as #4 or #5 consistency show quite a large degree of breakdown after 60 worker strokes and considerable additional softening upon further working to 300 strokes.

In the case of soda base greases, the degree of break-down on extensive working seems to be related more to how the grease is manufactured than to its soap and oil constituents, and there is no relationship between consistency grade and change on working as is the case with Calcium base greases.

Figure X shows change on working data for three soda base greases after 60 worker strokes and after 5000 worker strokes. Grease "A" was a milled product having an initial penetration of 260 and after the severe working of 5000 strokes still showed

FIG. 10



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relatively little softening. Grease "B" was an unmilled product which accordingly showed a very marked consistency change after 60 worker strokes, but after this initial working it remained quite resistant to further break-down, even after the 5000 stroke working. Grease "C" displays poor resistance to break-down on working, both on the initial 60 strokes and the additional working of 5000 strokes. These data indicate that the formulation and method of manufacture are controlling factors in the mechanical stability of soda base greases.

The matter of grease break-down on extended working, to simulate conditions of actual service, is apparently receiving considerable study by the industry and it would appear that this problem is one deserving of the further attention of the N.L.G.I.

OXIDATION

The Norma-Hoffman Bomb Test is the only method which appears to be in general use for the evaluation of the oxidation resistance of greases. Table XI shows test conditions reported in use by various laboratories.

TABLE 11

NORMA HOFFMAN BOMB OXIDATION TESTS

(110# Oxygen Pressure)

150°F., 2½% Bronze Filings catalyst.
175°F., no catalyst.
175°F., Copper catalyst.
210°F., no catalyst (Spec. AN-G-3).
210°F., 2½% Iron Filings catalyst.
210°F., 2½% Bronze Filings catalyst.
210°F., 2½% Brass filings catalyst.
210°F., Copper Strip catalyst.

Since many greases of good stability show very low rates of oxygen pressure drop, a variety of metal catalysts have been utilized to accelerate the oxidation processes and thereby shorten the test time. In general the test temperature of 210°F. is used for soda base or other high melting point greases and temperatures of 150° or 175°F. for Calcium and Aluminum base greases. There is general agreement that Norma Hoffman Bomb Tests should be run at temperatures below the melting points of the particular greases being tested so that the oxidation will progress in the plastic sample rather than in a melted and separated mass.

A cooperative test program was recently conducted by several laboratories to determine if the Norma-Hoffman Bomb Test would be satisfactorily reproducible in different laboratories using the same grease samples, the same type of apparatus, and the same general test procedure. The results of this work have indicated poor test agreement between laboratories and it appears that the details of test procedure and technique must be standardized much more carefully than they are at the present time before this test method can be considered satisfactory for inter-laboratory use.

There is considerable disagreement within the industry concerning the significance and value of Norma-Hoffman Bomb Tests and there are apparently numerous instances where the test has been both misinterpreted and misapplied.

Following is a summary of the scope and limitations of the Norma-Hoffman Bomb Test as compiled from the survey:

(1) The Bomb Test was originally developed to evaluate the suitability of greases used to pack anti-friction bearings subject to extended periods of shelf storage. When limited to this application, the test is generally considered to be most useful in developing greases which will have maximum shelf storage life with a minimum of undesirable deterioration as to gumming, thickening and acid formation.

(2) The Bomb Test has been found to be generally unsatisfactory for evaluating the oxidation resistance of greases under dynamic conditions, i.e. greases for lubrication of moving parts as contrasted to parts in storage.

(3) The test has been found unsuited for evaluating the storage life of greases made with residual type oils and seems to be limited chiefly to evaluating greases containing distillate type oils.

(4) There is general agreement that the results of Norma Hoffman Bomb tests cannot be interpreted too literally. In other words a grease having a Bomb "life" of 300 hours may be equally as good as a grease having a Bomb "life" of 400 hours, and the test cannot be used to predict differences within definite numerical limits. Greases having short Bomb "lives" may be considered as unsatisfactory for long time shelf storage use, but there is no established basis, nor has the test proved sufficiently precise, to permit differentiation between greases having reasonably long Bomb "lives".

(To be Continued)

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